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MECHANISMS OF SIMULTANEOUS LEARNING

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Northwestern University

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In various training situations it is common for the learner to be studying several different topics simultaneously. In our experimental work on simultaneous learning we restricted the tasks to the acquisition of two or more clearly distinguishable lists of words. Two questions dominated the research. The first question was concerned with negative effects that had been observed in earlier work. Subjects learned three lists in isolation for a trial before being given simultaneous learning on the three tasks.

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When a list was to be recalled, positive transfer from isolated to simultaneous learning was usually very high. However, when recognition memory was tested, or when memory for frequency of presentation of the words was measured, negative transfer was usually quite heavy. In the extreme case, it was as if the prior learning had no lasting influence on the memory. Our experiments sought to give a more thorough empirical characterization of these negative effects.

The second question asked about trade-off effects when a subject is learning two tasks simultaneously. If subjects are asked to learn an easy task along with a difficult task, it might be expected that more learning resources would be allotted to the difficult than to the easy task. The evidence from a number of experiments indicated that any substantial inequality in the allocation of resources did not take place unless the easy task was easy because the learner had been given practice on it before it was merged with another task for simultaneous learning. Other variables, which produced rather wide differences in the difficulty of the two tasks being learned simultaneously, did not result in differential allocation of resources.

The technique of using the simultaneous learning of two or more tasks appears to have considerable potential for studying many problems in learning and memory. The technique may be used to make new tests of theories developed from single-task learning. An illustration is a test of the theory which asserts that the spacing effect results from an attenuation of attention. In addition, however, the technique produces new phenomena which cannot be produced in single-task learning. An illustration of this is the finding in our earlier work that long-term retention is a direct function of the number of lists learned simultaneously. Another illustration is the negative effects (noted above) which occur when the learner is moved from isolated learning to simultaneous learning.

Final Report

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Benton J. Underwood

Northwestern University

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The experimental study of human learning and memory processes is nearly 100 years old. For most of that period the basic paradigm of research has been that of presenting the subjects a list of verbal units to learn and discovering the variables that influence the rate of learning and rate of forgetting.

In most training situations the learner is constantly shifting back and forth among various learning tasks that have been assigned. Thus, research using the single task is a representation for only a part of the learning which occurs in a training situation. It does not touch upon the phenomena which may evolve only because learners switch back and forth among tasks. It was to start to fill this gap in our knowledge that we initiated studies that came to be called simultaneous-learning studies. The first major work on this was published as a Technical Report in September, 1977, under the title "The Simultaneous Acquisition of Multiple Memories." In simultaneous learning the subject is given two or more tasks (we have used lists of verbal units almost exclusively) to study at the same time. This can only mean that the learner or subject moves back and forth between the lists. In all of the work done thus far we have used lists of items which are clearly distinguishable from each other. The memory for the lists may be tested by recall, or by recognition, or by other means, but the testing is separate for each list. In some studies the tests differed for each list. Thus, if the subjects were given three lists to learn simultaneously, one might be recalled, one might be tested by recognition procedures, and the other by requesting

frequency judgments of the items.

The research on simultaneous learning under Contract N00014-78-C-0661, which is the topic of this final report, concentrated on two problems. The first evolved from the results of an experiment reported in the Technical Report of July, 1977, entitled "Recall and Recognition of Tasks Learned Simultaneously." For reasons that are not relevant at this point, we carried out an experiment in which the subjects first learned three lists separately (one trial each), one list being recalled, one being tested for recognition, and the third required the subjects to make judgments of the frequency with which the items had been presented during study. Following the isolated learning trial on each of the lists, they were presented for simultaneous learning for additional trials. The critical data are those obtained on the first simultaneous learning trial. These data showed that the learning which occurred in isolation when recall was used transferred essentially 100% to simultaneous learning. However, for recognition and for frequency information, very heavy negative transfer occurred. The first problem, therefore, concerned factors which are involved in producing this negative transfer.

The second problem arose as a result of certain findings in the September, 1977 Technical Report noted earlier. Indirect evidence led us to suspect that learners did not easily change their allocation of resources for the different tasks under simultaneous learning. That is, it did not appear that across trials the subjects changed appreciably the amount of time spent on each of the various lists. However, as noted, direct tests were not made of this. Our second problem, therefore,

constituted a study of the conditions under which subjects did reallocate study time and under what conditions they did not.

The research on each of these two problems will now be summarized.

Negative Transfer for Recognition or Frequency Judgments

Our purpose was to develop a more thorough empirical characterization of the negative-transfer phenomenon which occurred in moving from isolated learning to simultaneous learning. To that end we asked about the effect of degree of learning before the transfer, about the effects of rates of presentation, and about transfer from simultaneous learning to isolated learning. During the course of the experiments we also replicated the original experiment and then replicated that replication with minor changes. In all of these replications we found the same negative effects first reported for recognition and for frequency judgments, but with high positive transfer for recall. We note this consistency to underline some problems we had in the other experiments where consistency was not always found. In these other experiments, where degree of learning and rate were varied, we found marked variations in the magnitude of the negative effects, and we have been unable to provide an accounting of this inconsistency. Perhaps even more disturbing, we found some inconsistencies within a single experiment. On a more positive note we found that the negative effects were tied to the direction of transfer; they occurred only when moving from isolated learning to simultaneous learning, not in the reverse direction.

One hypothesis for the negative effects was that the new items used on the tests for recognition and for frequency assimilation

following isolated study resulted in those items gaining an old "flavor." Therefore, on the test following the first simultaneous learning trial they would be a source of false alarms. This hypothesis was tested and found to have no basis in fact. There was reason to think that the negative effect might be caused by associations which develop between items presented together for simultaneous learning. A study showed that such associations do develop, and they do so quickly. It remains an hypothesis that they are involved in the negative-transfer effect.

The results overall indicate that under particular conditions (which can be clearly specified) a very heavy negative transfer occurs for recognition memory and for event frequency; for event frequency the negative effect may be complete in that the performance on the first simultaneous learning trial is no better than for a group not having the isolated learning trial. The negative effect for recognition is almost as great. Recall learning shows only strong positive transfer. We have not discovered the basis for the negative effects. Moving from isolated learning to simultaneous learning can be said to represent a change of context, but that really does not explain anything. Further, were change of context taken seriously as a cause, then we would need to rationalize the fact that moving from simultaneous learning to isolated learning (which is also a change in context) does not result in negative transfer. And, we would have to ask why change of context results in positive effects for recall.

<u>Allocation of Study Time</u>

In recent years there has been more and more attention paid to

strategies that a learner might develop. The work on this second problem might be viewed as being related to the emphasis on strategies. In most of the experiments we have carried out on the allocation of study time, the subjects have learned two tasks simultaneously. One of the tasks is called the standard task, the other the variable task. The standard task remained constant across all conditions of a given experiment. The variable task was changed across conditions to make it have varying degrees of difficulty. The learners were always under instructions to learn as many items from both lists as possible. Thus, the potential was present for strategy changes in that the subjects might come to spend more of their study time (more of their resources) on the standard task when the variable task was easy than when it was difficult. To conclude that reallocation of resources did occur required that the learning on the standard task differed as a function of the difficulty of the variable task.

The results have shown that reallocation does not occur except under quite special conditions. There are several cases where it did not occur. In free-recall learning, the background frequency of words had a substantial effect on rate of learning (a high-frequency list is much easier to learn than a low-frequency list) but it did not influence the performance on the standard task. Performance on the standard task was uninfluenced when the difficulty of the variable task was changed by varying the level of intrastimulus similarity for a paired-associate list. Meaningfulness differences for the variable lists had no influence on the learning of the

standard list. When the variable task was made up of abstract words in one case, and of concrete words in the other, the learning rate was markedly different, but the standard task was not influenced thereby.

In two cases a shift in resource allocation was found. In one of these the variable list consisted of presenting at one extreme, 36 different words (the same number as in the standard task), and at the other, nine words, four times each. The standard task was learned more rapidly when the subject had the nine words to learn, but this occurred only on the second trial, and did not occur when recognition was the response measure for both lists. In the second case subjects were given varying numbers of preliminary learning trials on the variable list before simultaneous learning. This had a marked *effect on allocation of resources* in that the greater the number of preliminary trials on the variable task the faster the learning of the standard task.

Putting the results together, it appears that before a reallocation of resources of a substantial magnitude will occur between two tasks, the learners must have had direct learning experience with the items in the variable task so that they essentially know them (have learned them) before or shortly after starting to learn the lists simultaneously. A subject may realize that a common word would be easier to learn than a nonsense syllable but this does not seem to cause him to redistribute his resources. Thus, there is less flexibility in the subjects behavior than might have been supposed.

If subjects are told to learn as many items as possible in both lists, they tend to divide their efforts consistently between the two lists. Only in extreme cases will there be a shift in this practice.

Some General Comments About Simultaneous Learning

In the approximately seven years that we have been working with simultaneous learning we have found it to add greatly to the versatility of a human learning laboratory. Although work with simultaneous learning may be more ecologically valid than work with single tasks, it seems self-evident that we must view them as complimenting each other when viewed in the perspective of pure knowledge seeking. From our previous work we know that many independent variables have the same influence on lists being learned simultaneously as they do for lists learned singly. Yet, simultaneous learning has unique characteristics in addition to its complimentary aspect.

Simultaneous learning may provide an appropriate vehicle by which theories, developed from single-list learning, may be tested. Three illustrations of this occur in the work being summarized. The age-old issue of the role of contiguity in associative learning was given a new test by simultaneous learning, and the results gave a very positive answer; items get associated in simultaneous learning even though the learner does not intentionally try to learn these associations. We also made a test of the hypothesis that the spacing effect is due to an attenuation-of-attention for the massed items. This hypothesis was tested (and supported) in simultaneous learning without using spaced items at all. We have also noted that

recall and recognition measures give quite different results in two instances in our data. Theoretically, this may well mean that the two measures result from different underlying processes, and our theories about them should be coordinated to this fact.

In addition to supplying tests of theories based on single-list learning, simultaneous learning produces new phenomena. The negative transfer in going from isolated learning to simultaneous learning is one such. Although not investigated in this particular contract period, we have shown in previous work that retention (as measured by recall) is a direct function of the number of different lists learned simultaneously. A difference in recall of 38% occurred for 24-hour recall between a list learned singly and a list learned along with two other lists. Our earlier work also strongly suggested that there would be equivalent differences in short-term memory.

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All of the research under this contract has been reported in two distributed technical reports, both under the authorship of Benton J. Underwood and Arnold M. Lund. One of these reports is entitled "Factors Involved in the Negative Transfer from Isolated Learning to Simultaneous Learning," the date being July, 1980. The other is entitled "The Effect of the Difficulty of One Task on the Simultaneous Learning of Another Task," the date being August, 1980. None of the work has been accepted for publication in standard journals as yet.

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